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Changes in Tear-Film Status and Ocular Surface Disease Index Score Following Prolonged Use of Face Mask

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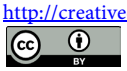

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Abstract

Background: Dry eye is characterized by tear film instability, decreased tear volume and a high Ocular Surface Disease Index (OSDI) score. Face masks have been linked to dry eye complaints in recent studies. **Purpose:** To evaluate the changes in tear-film status and Ocular Surface Disease Index (OSDI) score following prolonged use of face mask. **Design:** Cross-sectional study. **Method:** Patients between 18 to 70 years using masks regularly for at least 2 hours/day for at least 5 days/week from different eye-care centres in Dhaka were included. All subjects were divided into 4 groups. Mask use lasted approximately 2 hours/day in Group 1, 4 hours/day in Group 2, 6 hours/day in Group 3 and 8 hours or more/day in Group 4. Evaluation of symptoms, tear-film stability and tear volume was done by Ocular Surface Disease Index (OSDI) scores, Tear-film Break-Up Time (TBUT) and Schirmer-1 test. Average of right & left eye's Tear-film Break Up time (TBUT) and Schirmer-1 value were noted. **Results:** Total 100 patients were enrolled (n = 100). The TBUT ($p < 0.001$) and Schirmer-1 measurement ($p = 0.01$) were significantly lesser and Ocular Surface Disease Index (OSDI) score were significantly higher in patients using face-masks for longer time ($p < 0.001$). **Conclusion:** Patients who wore masks for prolonged time had tear film instability, reduced tear volume and higher Ocular Surface Disease Index (OSDI) score.

Keywords

Tear-Film Break up Time, Schirmer-1, Ocular Surface Disease Index (OSDI), Face-Mask

1. Introduction

The most essential protective element of the ocular surface is the tear film. The secretions from lacrimal glands, accessory lacrimal glands, goblet cells and the meibomian glands make up the tear film [1]. Unstable film, reduced tear volume, hyperosmolar tear and inflammation can lead to dry eye [2]. The prevalence of dry eye is more in Asia specially in underdeveloped and developing countries. Dry Eye Disease depends on numerous risk factors like occupation, socio-economic status, malnutrition etc. In West Bengal and Eastern India, Dry Eye Disease affects roughly 26% of people over the age of 30, with a female predominance. According to one study, dry eye affects 35% to 40% of Bangladeshi textile workers [3] [4] [5]. Typically, these patients present with grittiness, watering, burning sensation deteriorating over the course of the day, stringy discharge, transient blurring vision and ocular discomfort. Dry eye has association with many physiological factors (e.g. aging, menopause), pathological factors (e.g. Sjogren syndrome, lacrimal deficiency, meibomian gland deficiency, Diabetes Mellitus, Hashimoto's thyroiditis etc.), iatrogenic factors (contact lens, drugs, ophthalmic surgery etc.) and environmental factors (e.g. prolonged screen time, air conditioner, smokers etc.) [6]-[15].

Many studies have demonstrated that Dry Eye Disease, like other chronic conditions, can reduce one's quality of life. So, it is essential to diagnose and identify the pathology for proper management. Both subjective and objective evaluation is needed as the signs and symptoms often do not co-relate [16] [17] [18].

Since the declaration of COVID-19 as global pandemic, facemasks have been made mandatory all over the world to prevent the spread of the virus. As people have been wearing facemasks for several hours on a regular basis for more than a year, a significant rise of dry eye symptoms has been noticed in the Ophthalmology out-patient department throughout the world. This observation was first made by Dr. D. E. White, an American Ophthalmologist in June 2020. He named this condition as "Mask Associated Dry Eye" (MADE) [19] [20].

Some studies have predicted that people wearing facemasks for a prolonged period have been diagnosed with Dry Eye Disease due to tear film and eye-lid abnormalities [21]-[26]. Very few studies with small sample size have been done to evaluate the tear film status in face-mask wearers. The purpose of this study was to determine the status of the tear film and dry eye symptoms in mask wearers, which would serve as a foundation for future research on the topic and aid in the provision of evidence-based care to patients.

2. Materials and Methods

2.1. Participants

Patients aged 18 to 70 years who attended different eye-care centers in Dhaka city between February 1, 2021 and August 31, 2021 and wore facemasks for at least 2 hours/day for at least 5 days/week were included in this cross-sectional

study after sufficient consent was obtained. Non-randomized purposive sampling was done. Contact lens users, patients with history of refractive or intraocular surgery, Sjögren's syndrome, rheumatoid arthritis, parkinsonism, Lupus, previously diagnosed with dry eye or ocular surface disorder, anti-histamines and diuretics takers were excluded.

2.2. Methods of Assessment

The main outcome variables were TBUT, tear volume measured by Schirmer-1 and OSDI score of the subjects. Old age, female gender, prolonged screen-time, Diabetes Mellitus were potential confounders. After taking informed consent, relevant questions were asked to detect these risk factors. The duration of face mask use was used to split all subjects into 4 groups. The duration of wearing face-masks in Group 1 was around 2 hours/day, Group 2 was around 4 hours/day, Group 3 was around 6 hours/day and in Group 4 it was 8 hours or more/day on at least 5 days a week. The findings of the groups were compared to each other. The Ocular Surface Disease Index questionnaire (OSDI) was used to assess the symptomatology, and the scores were recorded. The Tear-film Break-Up Time (TBUT) and Schirmer-1 test was used to determine tear-film stability and tear volume respectively. The average of the right and left eye's result was used to create a single value. Relevant questions were asked to the patient to assess the risk factors of dry eye. The Schirmer-1 test was performed using a Schirmer paper strip (5 × 35 mm) and the length of wetting from the notch was recorded after 5 minutes. The cut off value for wetting was <10 mm/5min [27] [28]. TBUT was measured by instilling fluorescein 2% eye drops into the lower fornix. After several blinks, the interval between the last blink and appearance of first dry spot was noted. Less than 10 seconds TBUT was considered abnormal [29] [30]. The overall Ocular Surface Disease Index (OSDI) score was divided into four categories: normal ocular surface (0 - 12 points), mild (13 - 22 points), moderate (23 - 32 points), and severe (33 - 100 points) [31].

2.3. Statistical Methods

Continuous variables were reported as mean ± SD. ANOVA and the Wilcoxon rank-sum test were used to compare groups. The Chi-square test or Fisher's exact test were used to compare categorical variables, which were reported as proportions. Confounders that might predict changes in TBUT, tear volume, and OSDI score in various groups were identified using univariate and multivariate regression. All of the data was imported into Microsoft Excel and analyzed with SPSS version 22.

3. Results

In this study, we assessed 167 patients for eligibility initially. Sixty-five patients did not meet all the inclusion and exclusion criteria and 2 patients declined to participate. Hundred patients were finally confirmed as eligible (n = 100). The

difference among the demographics and baseline characteristics of the groups was not statistically significant; except for the male-female ratio (p = 0.02). Age of the patients, number of the diabetics and patients with long screen time in all 4 groups were almost similar (Table 1). The overall TBUT was 13.84 ± 1.84 seconds, Schirmer-1 was 21.18 ± 5 mm in 5 minutes and OSDI was 17.47 ± 15.18. Figure 1 and Figure 2 shows distribution of TBUT & Schirmer-1 measurement of all the groups with their different durations of wearing mask.

The difference among the groups' tear film stability which was assessed by TBUT, tear volume measured by Schirmer-1 and OSDI score was statistically significant (Table 2). The TBUT was shorter in groups with history of longer duration of face-mask use (p < 0.001). Schirmer 1 measurement also reduced significantly with the increasing hours of using face-mask (p = 0.01). Also, the Ocular Surface Disease Index (OSDI) score were significantly higher in patients who wore face-masks for longer time (p < 0.001). So, there was a positive correlation of OSDI and negative correlations of TBUT & tear volume (Schirmer-1) with the amount of duration wearing face-masks (Figures 3-5). Univariate regression analysis revealed for every 15 years increment in age, TBUT decreased by 0.5 sec (p = 0.002), Schirmer-1 reduced by 3.6 mm. (p < 0.001) and OSDI

Table 1. Demography of study population and inter-group comparison of baseline characteristics.

Variable	Total (n = 100)	Group 1 (n = 28)	Group 2 (n = 23)	Group 3 (n = 19)	Group 4 (n = 30)	P value
Age (Mean ± SD) years	46.5 ± 14.9	47.1 ± 17.9	47.8 ± 15.6	48 ± 11.4	44.1 ± 13.7	0.76
Male, n (%)	47 (47%)	16 (57.1%)	15 (65.2%)	4 (21.05%)	12 (40%)	0.02
Diabetic	23 (23%)	5 (17.9%)	7 (30.4%)	4 (21.05%)	7 (23.33%)	0.78
Long screen time	84 (84%)	21 (75%)	18 (78.3%)	17 (89.5%)	28 (93.3%)	0.2

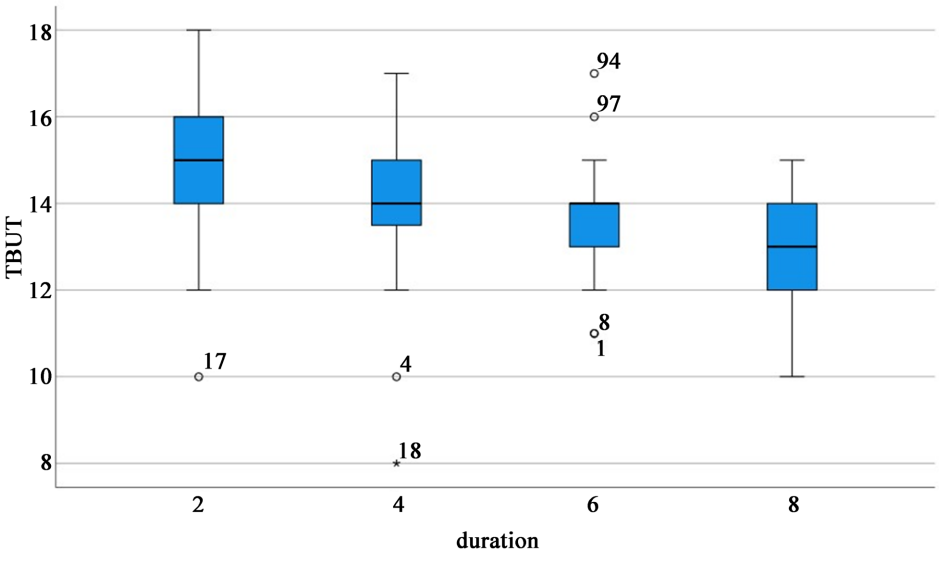

Figure 1. The median TBUT (sec) with interquartile range and outliers of 4 groups shown in a box and whisker plot.

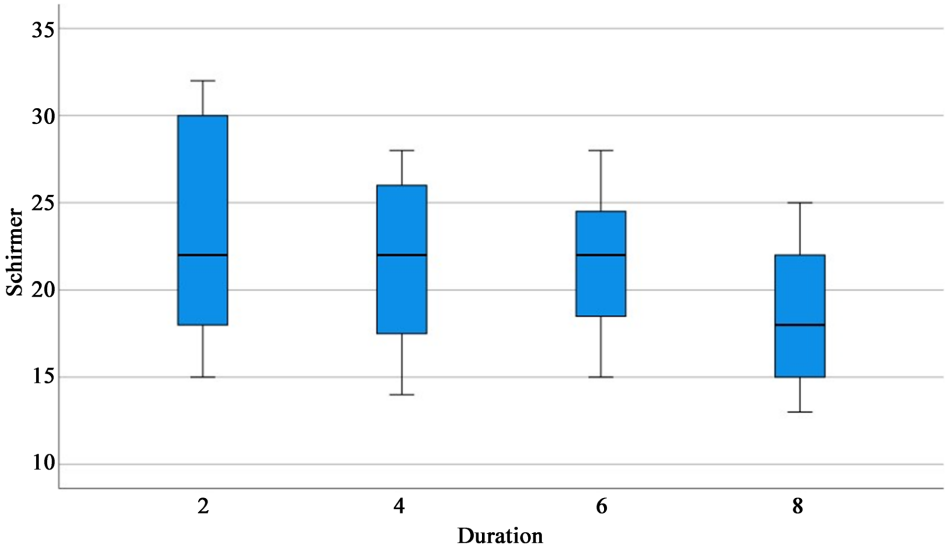

Figure 2. Median Schirmer 1 measurement with interquartile range & outliers of 4 groups shown in a box and whisker plot.

Table 2. Inter-group comparison of changes in TBUT, Schirmer-1 measurement and OSDI score (n = 100).

Variable	Group 1 (n = 28)	Group 2 (n = 23)	Group 3 (n = 19)	Group 4 (n = 30)	P value
Mean TBUT ± SD (sec)	14.8 ± 1.8	14.2 ± 2.1	13.6 ± 1.5	12.8 ± 1.2	<0.001
Mean Schirmer-1 measurement ± SD (mm in 5 min)	23.11 ± 6.2	21.6 ± 5	21.6 ± 3.8	18.8 ± 3.7	0.01
Mean OSDI score ± SD	11.8 ± 14.2	16.1 ± 15.6	19.6 ± 14.9	22.5 ± 14.7	< 0.001

TBUT: Tear-film Break-Up Time, OSDI: Ocular Surface Disease Index.

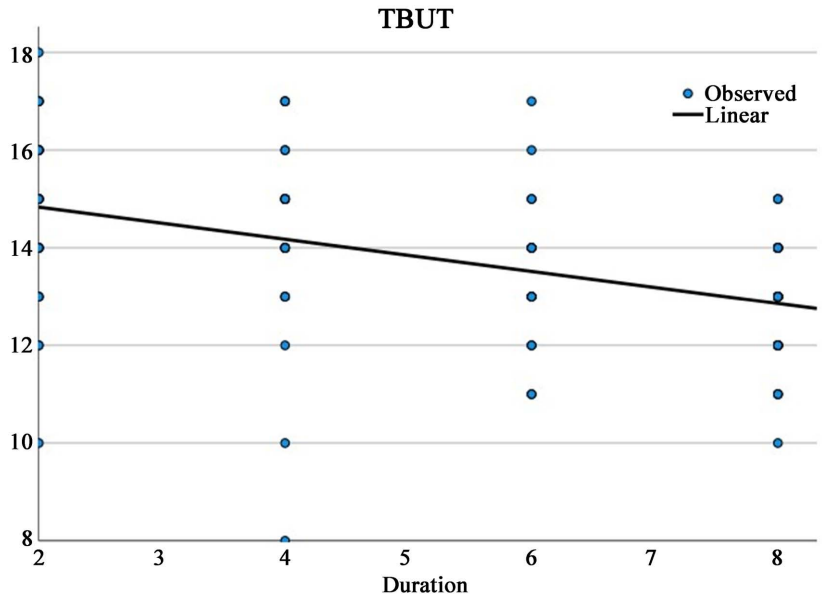

Figure 3. Linear graph showing negative correlation between duration of facemask use and TBUT (Pearson correlation = −0.427).

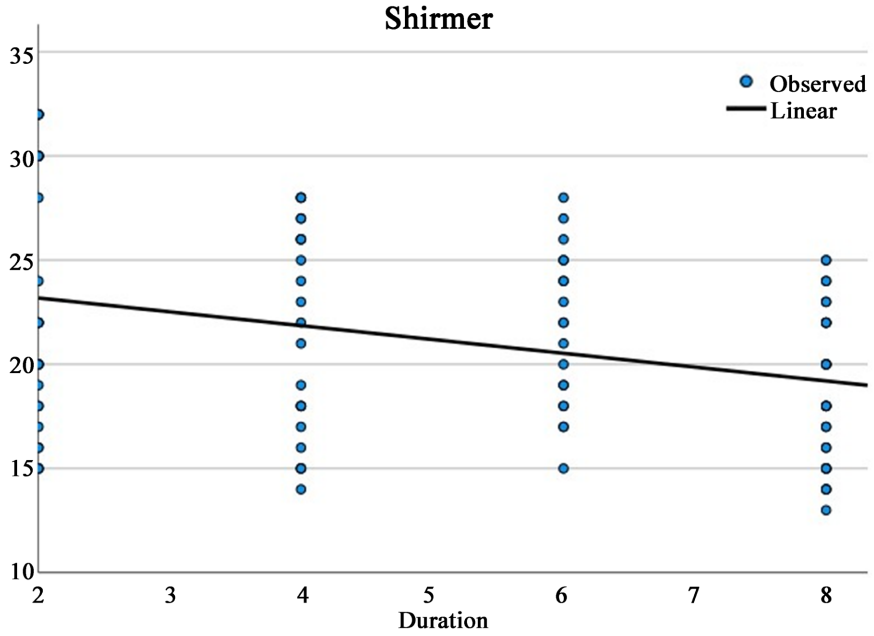

Figure 4. Linear graph showing negative correlation between duration of facemask use and Schirmer-1 measurement (Pearson correlation = −0.315).

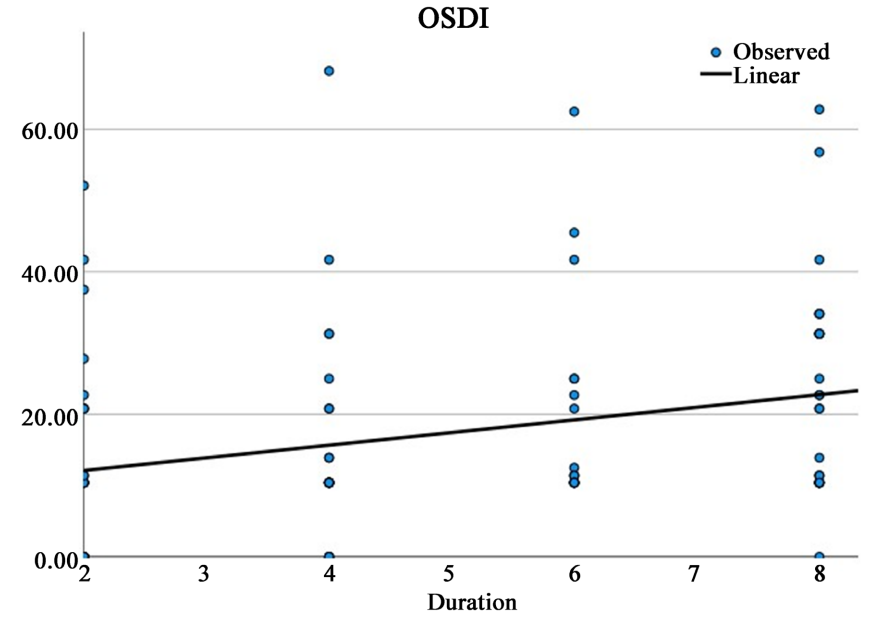

Figure 5. Linear graph showing positive correlation between duration of facemask use and OSDI score (Pearson correlation = 0.279).

score will increase by 7.6 ($p < 0.001$). Being diabetic increased TBUT by 0.4 seconds ($p = 0.047$), Schirmer-1 by 2.01 mm ($p < 0.001$) and reduced OSDI score by 5.1. ($p = 0.001$). For every 2.4 hours increase in the duration of wearing masks, TBUT decreased by 0.8 sec ($p < 0.001$), tear volume decreased by 1.6 mm ($p = 0.001$) and OSDI score increased by 4.2 ($p = 0.005$). But multivariate analysis revealed, every 15 years increase in age decreased TBUT by 0.6 sec ($p = 0.003$), reduced Schirmer-1 by 3.7 mm ($p < 0.001$), increased OSDI score by 7.1.

($p < 0.001$). With every 2.4 hours increase in mask usage per day TBUT decreased by 0.8 sec ($p < 0.001$), Schirmer-1 reduced by 1.97 mm ($p < 0.001$) and OSDI score increased by 4.81 ($p < 0.001$). Changes due to prolonged screen time and female gender among groups were not statistically significant (Table 3).

4. Discussion

In this cross-sectional study, we evaluated the changes in tear-film status and Ocular Surface Disease Index (OSDI) score due to prolonged use of face mask. We found that people wearing face-masks for longer period had tear-film instability, reduced tear volume and were more symptomatic. In groups with longer mask wearing time, the mean Tear-film Break-Up Time (TBUT) was shorter, the Schirmer-1 result was lower and the Ocular Surface Disease Index (OSDI) score was substantially higher than in groups with mask wearing time of 2 hours or less per day. With the increment in the duration of using masks, the results of the parameters tested worsened. We also found older age and Diabetes Mellitus negatively affects tear film stability, tear volume and Ocular Surface Disease Index (OSDI) score.

The Dry Eye Workshop (DEWS) committee has identified increased osmolarity and instability of tear-fim as the fundamental causes of Dry Eye Disease [32]. Similar to our study, Moshirfar [21] found worsening of corneal staining indicating loss of tear-film integrity in regular mask-wearers. Although they did not evaluate tear volume like our study, the study inculpated the evaporation of tear-film as the etiology of tear-film instability. Salami [33] conducted a study where AS-OCT of the tear meniscus (TM) were done at baseline and after 8 hours of wearing protective masks. There was 23% reduction in tear meniscus

Table 3. Univariate and multi-variate regression analysis to detect factors influencing tear film status and OSDI score

Variable with Interval	Univariate analysis β coefficient (95% CI)			Multivariate analysis β coefficient (95% CI)		
	TBUT	Schirmer-1 measurement	OSDI score	TBUT	Schirmer-1 measurement	OSDI score
2.4 hours/day increment in mask use	−0.43 (−0.47 to −0.19)***	−0.32 (−1.06 to −0.26)**	0.279 (0.55 to 2.99)**	−0.46 (−0.5 to −0.21)***	−0.39 (−1.1 to −0.56)***	0.32 (0.92 to 3.11)***
15 years increment in age	−0.31 (−0.06 to −0.01)**	−0.71 (−0.29 to −1.89)***	0.5 (0.33 to 0.68)***	−0.32 (−0.07 to −0.01)**	−0.75 (−0.3 to −0.2)***	0.47 (0.28 to 0.69)***
Male Vs Female	−0.13 (−1.19 to 0.27)	−0.05 (−2.55 to 1.46)	0.11 (−2.71 to 9.34)	−0.03 (−0.75 to 0.56)	0.06 (−0.72 to 1.84)	0.04 (−4.0 to 6.33)
Diabetic Vs Non-diabetic	0.2 (0.01 to 1.72)*	0.4 (2.45 to 6.8)***	−0.34 (−18.86 to −5.3)**	0.02 (−0.84 to 0.97)	−0.03 (−2.13 to 1.42)	−0.08 (−9.88 to 4.43)
Long screen time Vs no or less screen time	−0.007 (−1.03 to 0.97)	−0.098 (−4.05 to 1.39)	0.072 (−5.28 to 11.21)	−0.05 (−1.12 to 0.67)	−0.04 (−2.23 to 1.24)	0.05 (−4.9 to 9.22)

$p < 0.05$*, $p < 0.01$**, $p < 0.001$***; TBUT: Tear-film Break-Up Time, OSDI: Ocular Surface Disease Index.

height and 39.4% reduction in tear meniscus area. Reduced tear meniscus height indicates reduced tear volume. It has been detected that exhaled CO_2 rich air has the temperature of 36˚C - 37˚C. It has been hypothesized, this warm, humid air escapes through the upper gap of the mask and directly increases the osmolarity and hampers tear-film stability by evaporating the tear-film [34]. A prospective study by Mustafa Aksoy [35] evaluated 52 subjects who regularly wore masks for at least 8 hours/day. Mean Tear Break Up Time (TBUT) and Schirmer-1 was reduced after 8 hours of wearing masks without taping ($p < 0.001$). But, interestingly, after wearing taped masks for 8 hours/day for 15 days, the mean TBUT and Schirmer-1 were similar to the baseline results ($p < 0.001$). It seems preventing the contact of expired warm air with ocular surface helped to preserve tear-film stability and volume. One study showed, low air humidity can cause tear-film hyper-osmolarity [36] [37]. Again, the findings of these studies support the hypothesis of tear-film evaporation due to exhaled warm air passing through the upper opening of mask.

Like many previous notable research, in our study we found Ocular Surface Disease Index (OSDI) score was positively correlated with the duration of mask usage. Evelina Marinova [26] reported similar correlation and increased dry eye symptoms in people wearing masks for more than 6 hours/day. People using heavy medical masks were more symptomatic. Similarly, when Scalinci [38] compared the Ocular Surface Disease Index (OSDI) scores of 67 subjects 1 year apart, the median difference of the score was significantly higher in heavy mask users (>6 hours/day mask usage).

Many studies have stated that high CO_2 level in the tear-film causes reduction of p^H in the corneal stroma that stimulates nociceptors and ultimately leads to exacerbation of dry eye symptoms. This CO_2 also causes hypoxia and inflammation by producing reactive oxygen species, pro-inflammatory factors and leucocytes [39]-[45]. Supporting these findings, Mastropasqua [46] ascertained that use of face-masks for more than 3 months deteriorated Quality of Life (QOL) score, Tear Break-Up Time, ocular surface staining, raised cellular and molecular markers of inflammation like Dendritic Cell Density (DCD) and HLADR. The changes were more evident in previously diagnosed dry eye patients. They pointed out that TBUT was decreased as a result of inflammation and mucin loss rather than reduced Goblet Cell Density (GCD). Tight mask induced ectropion, incomplete blinking and air regurgitation through nasolacrimal duct have also been suggested for decreased tear film turn-over [47]. Dry eye symptoms were also found in COVID-19 patients. But the studies were not conclusive about whether it was due to ocular complications of COVID-19 or mask use [48]. So, it can be said that evaporation of tear-film, inflammatory mediators, mechanical effects of tight mask and COVID-19 complications all contribute together to cause Mask Associated Dry Eye (MADE).

On the contrary, many studies have found that women have a higher prevalence of dry eye and report more severe symptoms than men. Estradiol and testosterone levels play a critical role in meibomian gland function, hence meno-

pausal women are more affected [8] [49] [50] [51]. Because our study population was small and females were underrepresented, the lack of homogeneity may have skewed our findings. Moreover, in this pandemic, online classes and working from home have increased the screen time of most people. Several studies have implicated the association of prolonged screen time with reduction of Tear Break-Up Time due to evaporative type eye dryness [52] [53] [54]. According to studies, diabetics have hyperosmolar tear films due to hyperglycemia, decreased aqueous secretion due to microangiopathy of the lacrimal gland arteries and corneal nerve neuropathy. Our findings may have been influenced by the fact that we did not consider the glycaemic status of our diabetic individuals in this investigation [55] [56].

Our study surely had some other limitations which may have acted as potential bias; which includes unequal group size, absence of control group with no history of wearing masks. In addition, as this study was cross sectional, the divided groups were entirely based on the subjective feedback of the patients on duration of wearing masks. There was no strict monitoring on the number of hours using facemask.

In this pandemic era, the use of face-mask is undoubtedly mandatory to prevent spreading and protect oneself from COVID-19. Ophthalmologists should be aware that Dry Eye Disease may be caused or aggravated by regular prolonged use of masks and should examine the tear-film of the risk group as a part of routine check-up. Early diagnosis of Dry Eye Disease is essential as untreated conditions can affect one's quality of life and most importantly vision. Further studies with large sample size are required to investigate the bio-chemical changes in tear-film and Dry Eye Disease in mask users; so that it can be prevented.

5. Conclusion

In this study, patients wearing masks for longer time had tear film instability, reduced tear volume and higher Ocular Surface Disease Index (OSDI) score, which indicates the association of dry eye with prolonged use of face-mask.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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